RESEARCH SUMMARY

Exploring the Use of Computational Cognitive Models to Personalize Training

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ISSUE

- Training in the United States Department of the Air Force (DAF) is essential to develop, upskill, and sustain the abilities of airmen, guardians, and civilians.
- The DAF might leverage training and education technologies developed in industry, academia, and the government to maximize training effectiveness.
- Computational cognitive models of knowledge acquisition and retention are one potentially transformative training technology.
- These models can be used to develop empirically grounded curricula and to deliver personalized training.
- The DAF should develop and evaluate multiple courses of action (COAs) to find high-leverage applications of computational cognitive models to knowledge acquisition and retention.
- Second-language learning is one such application.

APPROACH

To evaluate the feasibility of applying cognitive models of knowledge acquisition and retention to DAF training and education, we conducted a market analysis and literature review of adaptive training technologies being developed by industry, academia, and the government. We then validated a computational cognitive model of knowledge acquisition and retention using a large dataset on second-language learning gathered in a naturalistic setting. Next, we developed statistical methods to calibrate the model to individual students and to groups of students. Finally, we conducted a detailed analysis of the goals, data-capture capabilities, and information technology system affordances of the Air Education and Training Command (AETC) Linguist Next (LN) Modern Standard Arabic Basic course. The synthesis of our analyses revealed that a specific computational cognitive model—the Predictive Performance Equation (PPE)—can be applied to the acquisition and sustainment of mission-critical knowledge. We demonstrate multiple COAs for applying PPE using the detailed case study of the LN Standard Arabic Basic course.

continued

KEY FINDINGS

- Adaptive training approaches that use computational cognitive models are relatively underexplored, yet they offer more benefits than other approaches.
- Of the computational cognitive models that have been proposed, the PPE has been demonstrated in many domains and settings.
- Building on previous work that has demonstrated PPE in real-world settings, we find that it also provides a valid account of second-language learning in representative settings.
- Of the elements covered in the LN Standard Arabic Basic course, PPE is most applicable to the acquisition and retention of task-critical vocabulary.
- PPE can be used to deliver empirically grounded recommendations for when to introduce and rehearse task-critical vocabulary in the LN curriculum at the classroom level.
- Student performance measures captured in the LN Standard Arabic Basic course provide information about mastery, yet they are not intended for personalized training.
- One promising COA is to deliver rehearsal activities and assess mastery of task-critical vocabulary using a separate software application designed for cognitive model–based personalized training.

RECOMMENDATIONS

- *The DAF should leverage cognitively inspired technologies to augment training.* These technologies are based on decades of learning-science research and have been shown to yield measurable benefits in terms of level of mastery and speed of learning.
- *The DAF should use computational cognitive models of knowledge acquisition and retention to deliver empirically based, personalized training.* Cognitive models are underexplored relative to other approaches to delivering adaptive training, yet they might be more suitable and might offer significant benefits beyond those methods. Furthermore, cognitive models provide a way to trace knowledge retention across long periods and during periods of disuse.
- *Air Force Research Laboratory (AFRL) should work with the DAF training enterprise to identify knowledge, skills, and abilities (KSAs) that underlie task performance to permit the application of cognitive models.* Furthermore, AFRL should work with the DAF training enterprise to tag training materials based on the KSAs they involve and to develop quantitative measures of KSA performance. This level of analysis is needed for cognitive model–based, personalized training.
- *AFRL should continue to develop statistical methods to calibrate cognitive models efficiently and effectively for individual students and groups of students.* Different implementations of the method used here, Bayesian hierarchical models, are needed to scale methods to larger numbers of students.
- *AETC LN should use a separate software application specifically designed for personalized training to deliver rehearsal activities of task-critical vocabulary.* The LN curriculum must satisfy several objectives. Thus, learning events cannot be fully tailored for cognitive model–based, personalized training. A promising alternative is to track all learning activities that students complete but to limit personalized training to a separate application that complements the full curriculum.

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